

FLEXLAB for Integrated HVAC – Use Case

Can industry increase the effectiveness of low-capacity, low-energy cooling systems for both retrofit and new construction applications?

The Challenge

Radiant cooling, chilled beams, displacement ventilation, and UFAD systems pose tremendous potential to lower cooling energy-use and deliver thermal comfort. However, adoption of these technologies has largely been limited to new construction applications in which thermal loads can be lowered, and controlled, when integrated with building envelope and interior lighting designs. These systems' capacity, and effectiveness, in meeting thermal load and comfort requirements of perimeter spaces, is a result of their interactions with the building façade and interior loads from lighting and other devices. Understanding how these elements affect system performance will illuminate opportunities to guide product, system, and controls design, and will suggest key upgrades to enable the use of these systems in retrofit applications.

For example, it has been understood that convection plays a large role in maximizing the cooling output of radiant panels or slabs. However, interactions and impact of convection that occur in typical buildings (e.g. convective effects from lighting systems and facades) are not well understood. With further insight into thermal performance impacts on radiant cooling, opportunities will emerge to **work synergistically with key lighting and façade retrofit systems to increase cooling effectiveness** under various operating conditions.

What do designers, engineers, and manufacturers need to develop advanced cooling systems capable of **delivering low-energy cooling solutions, while maintaining indoor environmental comfort** and occupant satisfaction?

FLEXLAB offers a unique opportunity for industry and researchers to collaboratively solve 'stretch' problems of this nature. **FLEXLAB** provides a path to solutions that cannot be found anywhere else in the world.



Chilled water supplied to a radiant cooling system.

| Testbed Capabilities | Performance Parameters and Benefits |
|---|--|
| Horizontal and vertical interior surface temperature measurement | Air and radiant temperature distribution of the space, relates to thermal comfort |
| Room imaging and visualization | Space thermal distributions |
| Lighting system and fixture power | System energy use, and peak demand; energy savings vs. 1980's base-case in twin cell |
| Temperature and flow of HVAC utilities | HVAC thermal loads |
| HVAC energy use | HVAC impacts; whole-building or zone energy savings due to retrofit system |
| Reconfigurable interior spaces | Create multiple zonal conditions – perimeter and core applications |
| Reconfigurable glazing | Impact of glazing on convection, thermal loads, radiant cooling output, energy and thermal comfort |
| Reconfigurable shading | Impact of shading on convection, thermal loads, radiant cooling output, energy and thermal comfort |
| Robust data acquisition, accommodation of additional instrumentation | Flexibility to integrate experiment-specific measurement with existing testbed sensors |
| Ability to interoperate and execute control across a variety of platforms and devices | Flexibility to test diverse systems and components, control solutions, and proprietary systems |

Starting Point

A manufacturer has a **radiant cooling product** and is interested in evolving its application in the retrofit and new construction markets. The radiant cooling product has been bench-tested, component tested, and demonstrated in a room environment, isolated from interactions with the wider array of building interior systems and convective sources. It has not yet undergone extensive long-term performance testing for interactions with, and impacts of, interactions with various grades of glazing and shading systems, with continuous high-resolution field-measured data.

Solution Pathway

System **performance validation** in **FLEXLAB** with identical side-by-side test cells.

The manufacturer conducts a field test, leveraging testbed measurement capabilities for energy performance and occupant comfort assessments that were not possible in the manufacturer's in-house facilities.

Immediate Outcomes

- Cooling & convective capacity effects of facades and lighting systems.
- Energy, thermal load and comfort performance metrics.
- Validation of sequences of operations, **system energy savings relative to a base case cell**.
- Holistic archival set of **high-quality field-measured data** (dozens of points) for use in manufacturer documentation, publications, and design information for practitioners.
- Comprehensive experimental results and information to adjust system control logic, or component performance, if energy or comfort targets are not met.

Extended Validation & Deployment Opportunities

- Conduct performance tests in **FLEXLAB's rotating testbed** to determine performance under diverse orientations.
- Introduce occupants through **human subjects testing** in the 1980s, 2010, 2013 or net zero testbeds – shift experimental focus to occupant satisfaction and personal control.
- Use the virtual design testbed and simulation tools, like Modelica, to develop robust calibrated models; **partner with LBNL researchers with subject matter expertise**.
 - Use field-measured data to **extend experimental findings to diverse climates, room geometries, envelope, and HVAC systems**.
- Work with LBNL researchers to **validate radiant cooling simulation algorithms** for use in annual energy simulation platforms such as EnergyPlus.
- Identify **low-energy controls and operations** strategies.
- Build partnerships with **early-adopter testbed members** to conduct scaled demonstrations in real-world buildings across the nation.
- Use experimental data, in combination with access to **utility/state testbed members** to expose benefits to emerging technology and new incentive programs, and for future code requirements.
- Provide anonymized system design and operational performance data to **members of the AE community** using the virtual design testbed.

References and Further Reading

Bourassa, N, Haves, P, Huang, J. A Computer Simulation Appraisal of Nonresidential Low Energy Cooling Systems in California, LBNL-50677.